APPARATUS FOR THE PRODUCTION OF CONTINUOUS GLASS FIBERS

Original Filed May 29, 1961 3 Sheets-Sheet 1

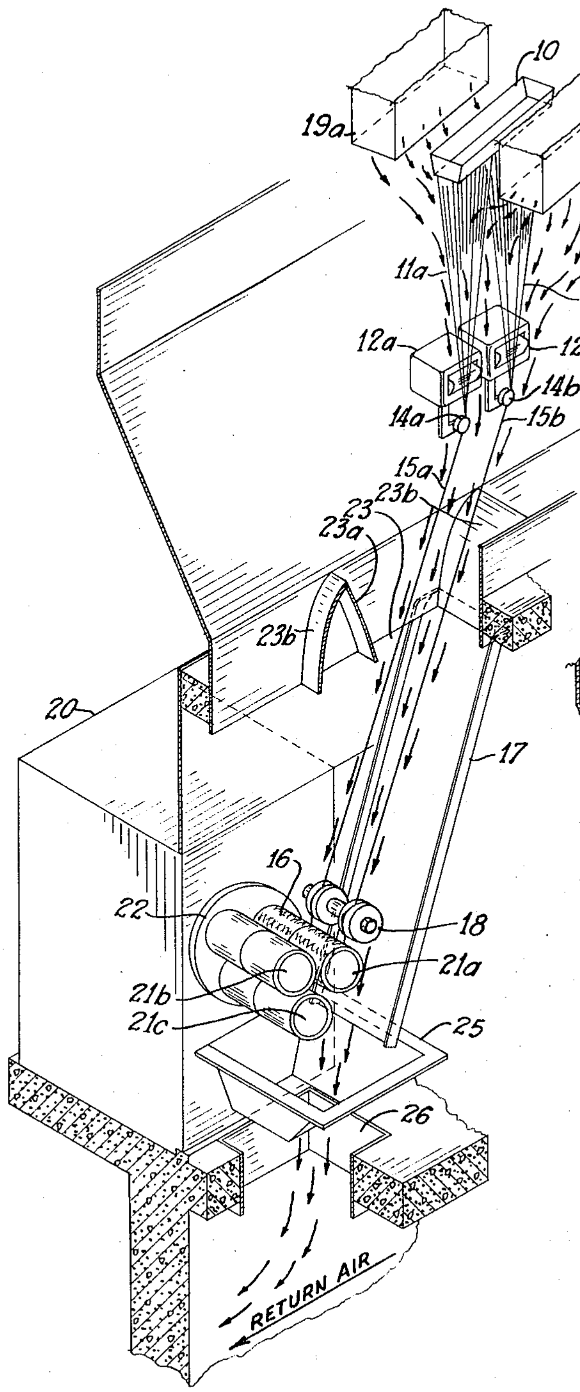

Fig. 1

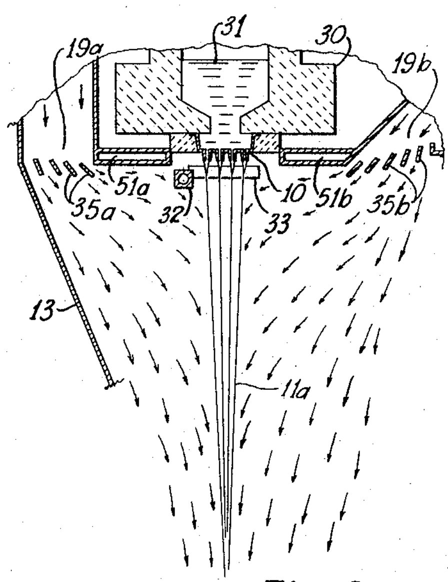

Fig. 2

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APPARATUS FOR THE PRODUCTION OF CONTINUOUS GLASS FIBERS

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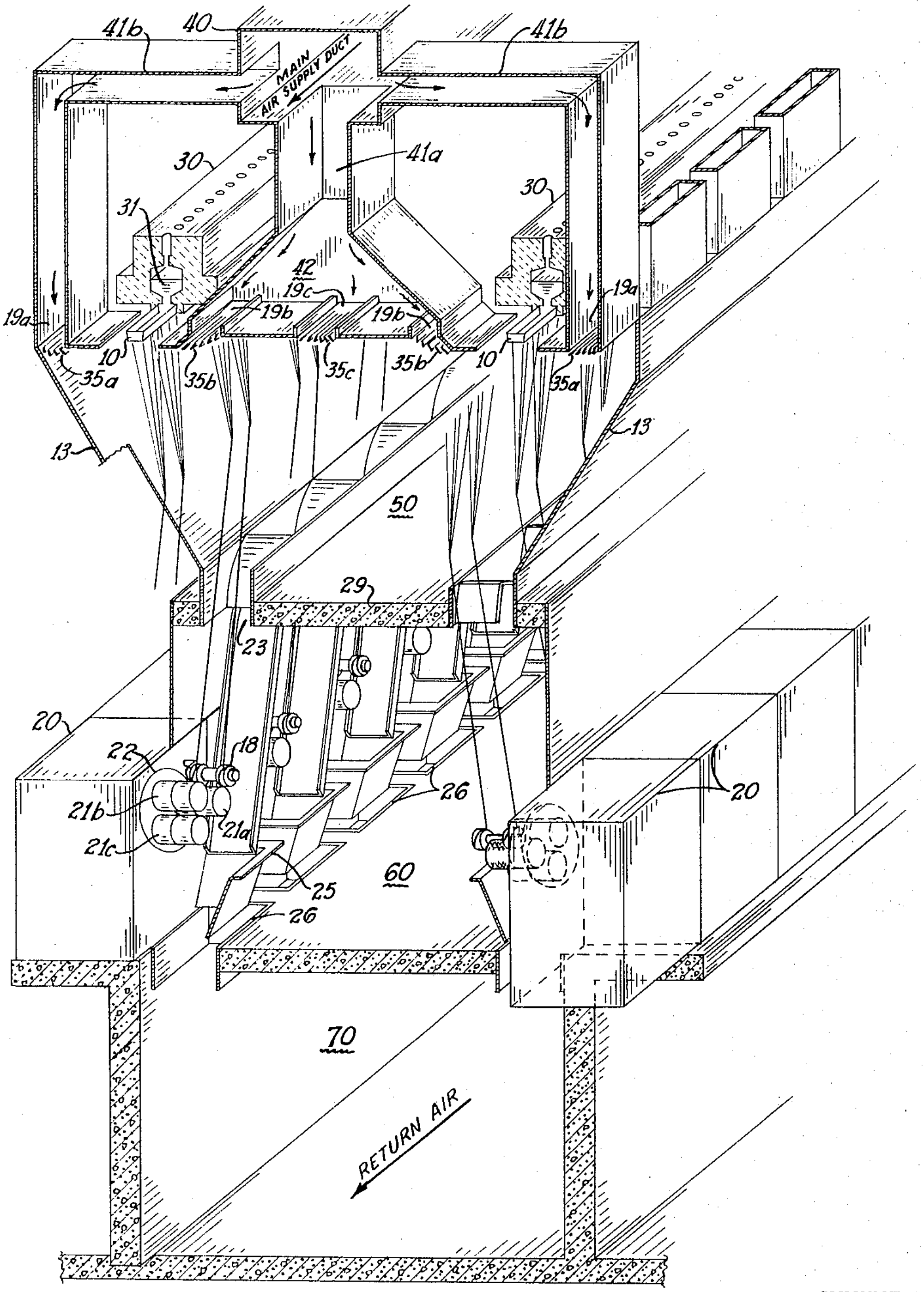

Fig. 3

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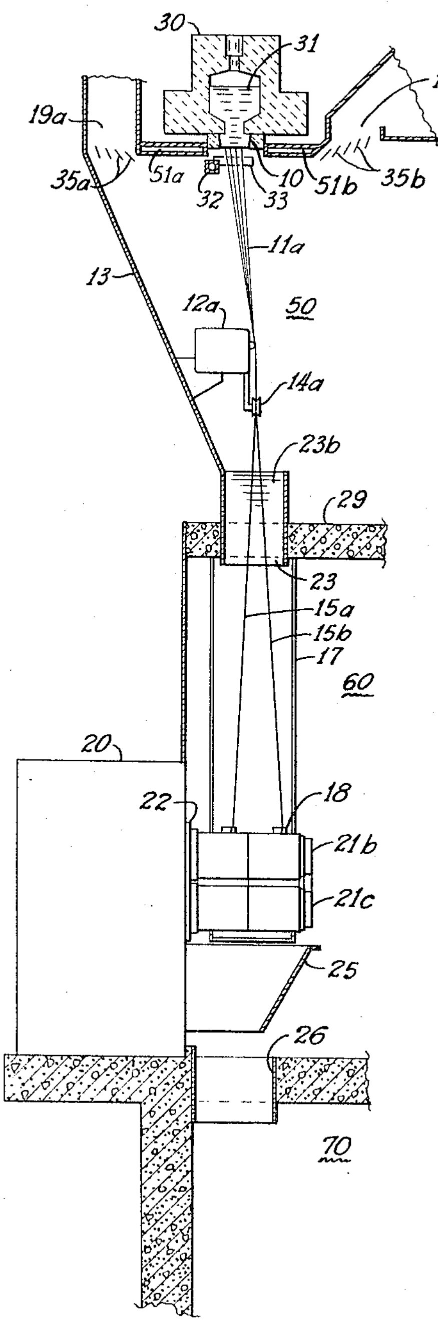

Fig. 4

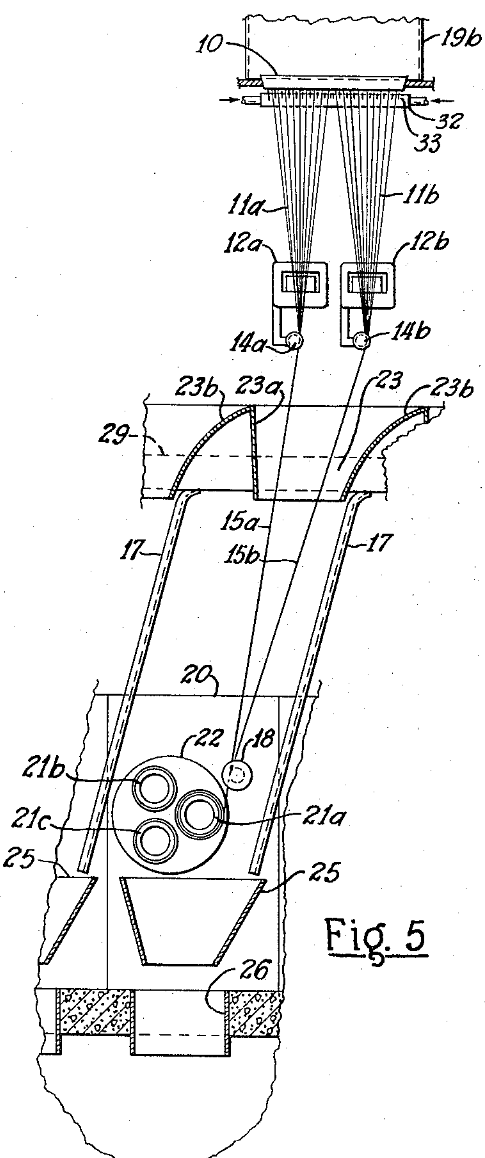

Fig. 5

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3,304,163

APPARATUS FOR THE PRODUCTION OF CONTINUOUS GLASS FIBERS

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Continuation of abandoned application Ser. No. 113,525, May 29, 1961. This application Mar. 10, 1966, Ser. No. 541,883

3 Claims. (Cl. 65—11)

This application is a continuation of my prior application Serial Number 113,525 filed May 29, 1961, now abandoned.

This invention relates to the production of fibers of heat-softenable materials and more particularly to a novel method and means for the attenuation of continuous fibers from molten streams of heat-softenable material.

Continuous fibers can be produced of heat-softenable materials such as glass at extremely high rates of speed which commercially range in the order of 8,000 to 15,000 feet per minute, and in the laboratory at rates in the order of 30,000 to 50,000 feet per minute and more. In the usual commercial arrangement for producing such fibers, the fibers upon formation are drawn from streams flowing from a molten source whereupon the fibers are grouped into a strand and collected into a package. The collection unit is conventionaly located a distance below the source of the molten streams sufficient to allow them to cool appreciably and to be supplied with sizing material for lubricity and integrity before being collected. Because the continuous fibers are moved at such high velocities, however, a considerable amount of air from the surrounding atmosphere is drawn with them toward the zone in which they are collected. In fact, the filaments and the strand formed therefrom usually move at such high rates of speed that the fiber-forming assembly could serve as an air pump.

Such huge quantities of air moving with the fibers, however, causes difficulty in maintaining continuity in the forming operation. Breaks in individual filaments occur more and more frequently with each increase in velocity because of the progressively greater effect air turbulences have in the immediate fiber-forming zone and along the path of movement of fibers. Economic practicability of operation with the increasing speeds made possible by the continued improvement of winding equipment coming into commercial operation accordingly dictates that the effects of turbulence due to the huge quantities of air being moved must be minimized or eliminated.

More specifically, because of these huge quantities of air, tension difficulties frequently arise in the immediate forming zone due to back-and-forth and up-and-down movements of uncontrolled turbulent air currents along the path of movement of the fibers and strands. Tension transients are thus generated which result in instabilites in continuity of attenuation of the fibers from the streams of material flowing from the molten source. Such turbulence in the flow of air additionally results in the tendency for foreign particles to be drawn into the fiber-forming zone, thereby further promoting disruption in the continuity of attenuation. Such disturbances also cause variations in the diameter of the fibers being produced as well as the inclusion of the foreign particles in the material of the fibers which reduce the strength of the individual filaments. Extraneous matter such as sizing or binder dust, glass particles, dirt brought in by operators, etc., are all susceptible to being blown about in the general vicinity of the fiber-forming operation. Since the fibers reach such a high velocity within only a short distance below the feeder, tendencies for turbulence and foreign particles to cause instabilities extend over an appreciable portion

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of the path of the fibers to the collection zone. The variances caused by the pumping and turbulent action also cause instabilities in the dynamic condition and are such that with lack of provision for the accommodation of air moved by the fibers, limitations exist upon the speed at which the fibers can be attenuated in commercial installations.

In view of the foregoing, it is a principal object of the present invention to provide a more economical system for the production of continuous fibers in which the instabilities caused by the movement of large quantities of air with high velocity attenuation of fibers are effectively minimized.

Another object of the invention is to provide a more stable and cleaner arrangement for the production of continuous fibers in systems where fibers are attenuated from streams of heat-softened materials.

A further object of the invention is to provide cleaner and more stable dynamic atmosphere conditions in the space surrounding the fiber attenuation zone in systems where continuous fibers are produced by attenuation from streams of heat-softened material.

A still further object of this invention is the establishment of controlled dynamic atmospheric forces of magnitude such that extraneous atmospheric transients or disturbances which might be encountered in the space surrounding the immediate fiber-forming zone will have relatively insignificant effect on the formation of fibers in comparison to their otherwise disrupting character in a more static or quiescent atmospheric environment.

A still further object of the present invention is the provision of a controlled dynamic environment which will individualize or isolate fiber-forming operations in each fiber-forming position where production facilities include a multiplicity of forming positions aligned in side-by-side relation in a bank, the controlled atmospheric conditions being of such character that little or no effect is felt by any one of the associated positions due to disruptions in operation of any other position in the bank.

In brief, the above objectives are attained in accordance with the broad concept of this invention by supplying air at the general level of the fiber-forming zone and establishing a reduced pressure at a general level below the strand collection zone so that the air moved due to the high velocity of filaments and strands is constantly removed from the collection zone and replaced at the feeder level with little or practically no air recirculation occurring along the length of travel of the fibers.

Additionally, in accordance with the invention, the air is supplied in the form of fresh air curtains about the immediate fiber-forming zone in each position so as to shield as well as isolate each forming position from the surrounding atmosphere. The air curtains are provided in the form of drafts of air projected downwardly adjacent the feeder. In so supplying and directing air under pressure adjacent the feeder, the present invention utilizes the finding that less disrupting effect is experienced from the constant presence of an applied force in comparison to a sudden transient or shock application of such force. Additionally, the arrangements of the invention effect the isolation of fiber-forming operations from contaminants that may be present in the surrounding atmosphere.

A feature of the invention lies in the fact that isolation of each position in a bank of fiber-forming positions by air curtains not only reduces the influence of such positions on operation of adjacent forming positions, but also allows pre-establishment of uniformity of output for an entire bank by reason of the individualization of each position.

A further feature of the invention lies in the fact that not only do air curtains associated with each fiber-forming position produce a controlled dynamic atmosphere for the operating system, but also provides air stripped of contaminants and cool air for operators in the operating space.

Other features and advantages of this invention will become apparent as the description progresses in connection with the accompanying drawings in which:

FIGURE 1 is a somewhat schematic, partially sectionallized perspective view of an assembly of apparatus comprising a position for producing continuous glass fibers in accordance with the principles of the present invention;

FIGURE 2 is an enlarged side elevational view in part of the apparatus arrangement in the immediate fiber-forming zone of FIGURE 1;

FIGURE 3 is a partially sectional view in perspective of a plant layout for a plurality of fiber-forming positions, such as that illustrated in FIGURE 1, in which the forming positions are aligned in side-by-side and in cross aisle relation in a forming room fully enclosed and supplied with air in accordance with the principles of the present invention;

FIGURE 4 is a sectional side elevation view of a single fiber-forming operation illustrating in more detail the arrangement of components in a fiber-forming position with air supplied from each side of the feeder in accordance with the principles of this invention; and

FIGURE 5 is a sectional front elevation view of the fiber-forming position illustrated in FIGURE 4.

In greater detail, the fiber-forming position of FIGURE 1 includes a feeder **10** which is supplied with a molten glass from a source such as a marble melting unit or a forehearth of a batch melting tank as illustrated in FIGURE 3. The molten glass flows as streams from orifices in the feeder **10** through a shielded zone under the feeder. The streams are attenuated into two groups of filaments **11***a* and **11***b* under the influence of the winder **20**, which applies forces to the filaments by way of the strands **15***a* and **15***b* formed of the separate groups of filaments **11***a* and **11***b* respectively. Prior to being gathered into strands **15***a* and **15***b* at gathering members **14***a* and **14***b*, the filaments **11***a* and **11***b* are supplied with a sizing fluid by being drawn over sizing applicators **12***a* and **12***b* respectively.

The shielded zone adjacent the feeder is illustrated more clearly in FIGURE 2 wherein the orificed tips of the feeders from which the streams of molten material flow are divided by a series of parallelly aligned fin-like shield members **31** of high temperature material which subdivided the streams or forming cones from which the fibers are attenuated into smaller groups so that each cone has a shield member disposed in adjacent heat absorbing relation therewith. The fin members **31** extend from a common fluid cooled support manifold **33** which removes heat from the fins to maintain them in cooled condition for absorption of heat from the forming cones. The orificed tips and shielded zone, namely the immediate fiber-forming zone, can be recessed within the ceiling structure as shown in FIGURE 2, and as further described hereinafter with reference to FIGURE 4.

The winder **20** as illustrated is a triple collet automatic transfer unit in which each collet has a double length to accommodate two collection packages in side-by-side relation, one for each of the strands **15***a* and **15***b*. Each strand is wound into a package on one-half of a double collet **21***a*. One collet is always in position to collect the two strands while the two additional collets, upon removal of packages which might be present thereon, are ready to be indexed into the collection position by step positioning of the rotary turret **22** on which they are mounted. Thus, upon completion of a given pair of packages on the particular collet in the collection position, an immediately following collet can be brought into position to continue collection of the strand without interruption in the continuity of attenuation of fibers from the feeder, thereby maintaining stability in the rate of removal of material flowing from the feeder. A double element traverse unit **18** moves the two strands laterally across the width of the respective packages into which they are being wound to build up the packages on the collet in accordance with a predetermined package-forming program.

In looking at the air flow arrangement of the invention in greater detail, it should be in light of the knowledge that the delicateness of the fiber-forming operation exists because the molten material supplied from the feeder **10** is extremely fluid and subject to disruption even from the application of only slight transient forces, such as from uncontrolled puffs of air eddies moving transverse to the direction of movement of material being attenuated into the fibers. Additionally, in this regard, the application of transient forces from extraneous uncontrolled conditions anywhere along the length of the filaments **11***a* and **11***b*, as well as along the length of the strands **15***a* and **15***b*, is transmitted upwardly to the fluid material at the feeder and tends to effect a disruption in continuity of attenuation. With this in mind, it has been found that if air is supplied under pressure on either side of the feeder and is then guided downwardly along the path of the filaments in the direction of the winder and removed from the winder zone, that production continuity can be improved immensely. Such improvement apparently arises because the downward channelling of the air with the moving fibers overcomes the tendencies toward uncontrolled upward drafts of air in the form of eddies, or if eddies do arise, they are conveyed downwardly with insignificant effect on fiber formation. To accomplish this result, air is supplied in the present instance from opposite sides of the feeder such as from oppositely disposed duct outlets **19***a* and **19***b*. When so released, the air acts somewhat like a screen or a curtain on either side of the feeder in the immediate zone of formation of the fibers from the fluid material.

The flow of air from the ducts is illustrated in FIGURE 1 by arrows which show that the air introduced from positions lateral of the feeder is drawn in the direction of movement of the filaments and the strands formed therefrom as the strands are moved to the winder **20**. The air is then exhausted at a lower level below the collection zone to assure that the flow is constantly in the same direction with a minimum tendency toward recirculation as extraneous eddies along the path of the filaments and strands.

In order to facilitate practical handling and observation of fibers during formation, the conventional fiber-forming position is divided into two levels, namely the sliver or fiber-forming level **50** and the winder level **60** separated by a floor **29** spaced under the fiber gathering points. Accordingly, an opening **23** is provided in the floor **29** sufficiently large to accommodate the air supplied from the outlets in the forming level. To promote smoother and more uniform passage of the air through the opening **23** between the two levels, the walls defining the opening can be contoured for lower resistance. In this respect, the back and front sides **23***a* and **23***b* of the opening **23** are made of arcuate low air resistance members forming a Venturi-like passage.

In order to channel the air further along the path of the strands to the winder, guide chutes **17** formed of longitudinal planar members are provided on opposite sides of the path of travel of the strands. The pair of chute members **17** extend from the arcuate air guide members **23***a* and **23***b* down to a level below the collection zone at the collet into which the strands are being packaged. Each of these chutes **17** extend to an open hopper shaped funnel, or what might be termed a guide frame **25** disposed above an opening **26** between the winding level **60** and the basement or exhaust level **70**. The funnel members which serve both as an air and waste channel at each forming position may be integral with the floor openings **26**, or may be spaced slightly above the openings to provide gaps at the floor level to facilitate floor cleaning.

Air is guided from the winding level **50** through the air guide members **25** and through the floor openings **26** by reason of the establishment of a negative pressure in the basement or exhaust level below the entire fiber production area. The negative pressure can be established by exhaust fans located immediately under each opening **26**, or, as represented by the air flow arrow in FIGURES 1 and 3, a main exhaust fan intake can be provided at the basement level for extraciton of air to establish the reduced pressure condition which will cause the air to flow downwardly from the upper levels along the paths of the fibers and the strands during formation. The exhausted air is moved to equipment which filters, cools and fixes the moisture content, whereupon the air in conditioned form is fed to the supply duct by a separate blower. Alternately, the withdrawn air can be exhausted to the outside atmosphere and replaced by fresh air which can be conditioned before distribution through the supply ducts.

FIGURE 3 illustrates the manner in which a number of operating positions can be aligned in side-by-side relation and in a cross-aisle relation for efficient production of continuous fibrous glass strands within a minimum of space and allow efficient observation and handling of packages by machine operators. The fiber-forming positions as so aligned lend themselves additionally to the multiple level operation wherein the fibers are formed at the upper forming room level **50** and the collection is accomplished by winders at the winder room level **60** while the basement **70** serves as an air exhaust tunnel. In this arrangement, the air is supplied from above the forming room level through a ceiling comprising a plenum air duct assembly which along with the feeder **10** and associated cooling panel structures **51***a* and **51***b* form a unitary ceiling which in turn, in association with the sidewalls **13**, form the upper structure of the enclosure for the operating positions.

Turning in greater detail to the air supply system of FIGURE 3, a main supply duct **40** is located above the forming room ceiling and is connected to an air supply means such as a central blower fan (not shown) which recirculates air supplied from the basement exhaust tunnel **70** to suitable cooling and humidity conditioning apparatus (not shown) prior to introduction to the main supply duct **40**. Air deficincies due to losss in the system are made up by supplemental fresh air supplied to the conditioning apparatus from outside the forming enclosure. After conditioning, the air is supplied under pressure to a central plenum chamber **42** located centrally over the aisle between the two rows of forming positions in the forming room **50**. The air is supplied to the plenum chamber **42** by way of a passageway **41***a* and is released into the forming room by way of the outlets **19***b* and **19***c* each located laterally of a fiber-forming feeder, while outlets **19***c* are central openings in the room which add to the air of the forming room and equalizes the pressure near the ceiling level to reduce tendencies for generation of lateral air eddies. Air is also supplied from the main supply duct **40** to the outlets **19***a* on the opposite sides of each of the feeders by way of air passageways **41***b* which branch off from both sides of the main supply duct **40** and lead down over the two lines of feeders **10** and to a position adjacent each of the feeders at the opposite walls **13**.

As an alternate to this arrangement, air can be introduced into the forming room from a ceiling which is perforated and provided with an open grillwork across the entire work space to effect a more completely distributed area introduction of air. The desirable aspects of the air curtains, however, and the economics of supply of air requires the more concentrated introduction with dispersion mechanisms to effect uniformity.

Molten glass **31** is supplied to each of the feeders **10** by way of a forehearth **30** connected to a melting tank and extending over the plurality of winders **20** located in aligned relation along the length of the winder level **60**. As may be seen in FIGURE 4, each pair of outlets **19***a* and **19***b* supplying air on opposite sides of the feeder **10** are also located on generally opposite sides of the forehearth **30**. Since the temperature of the glass supplied to the feeder **10** is usually in the order of 2,300° to 2,600° F., a considerable amount of heat is present in the vicinity of the feeders. In order to reduce the tendency for such heat to increase the temperature of the air introduced from the outlets **19***a* and **19***b*, cooling panels **51***a* and **51***b* are provided assembled in the ceiling adjacent each feeder to reduce the transmission of heat from the forehearth to the conditioned air introduced from the outlets.

The panels **51***a* and **51***b* are generally planar in configuration and patterned to accommodate the feeder. Passageways are provided in the panels for circulation of a suitable cooling fluid, such as cool water. The panels thus provide a cool surface over which the air will pass when ejected from the outlets for movement in the direction of the feeder to the filaments being attenuated therefrom. In this way, an appreciable rise in temperature of the air is prevented, even in spite of its flow in close proximity to the extremely high temperature material being attenuated from the feeder **10**. Additionally, such fluid cooled panels provide an element of temperature control for the air fed through the main supply duct. It has been found that when such panels are not cooled, the temperature in the area of the fiber formation is considerably increased thereby causing thermal instabilities which reduce efficiency of production due to a greater number of breakouts of fibers being formed.

The panels are also aligned under the portion of the forehearth **30** adjacent the feeder in order to seal off a possible reverse movement of air upwardly. The panels as so arranged form an opening below the forehearth through which the feeder **10** is made accessible. The feeder thus can be partially recessed within the ceiling panel opening as illustrated more clearly in FIGURES 2 and 4. Correspondingly, the cone shield members, such as the type described in U.S. Patent 2,908,036, issued to R. G. Russell on October 13, 1959, can also be partially recessed if desired to assist in the protection of the critical portion of the immediate fiber-forming zone in which the glass is most fluid. The velocity of the material moving within the shielded zone is relatively low compared to the velocity of the fibers outside of the shielded zone as they are drawn from the apices of the fiber cones. Accordingly, the need for replacement of the air in the immediate fiber-forming zone is not as great as that required by the movement of the fibers immediately upon formation. Thus recessing of the shielded zone in which the cones are present surrounds the zone where little air replacement is necessary, yet allows a free space where replacement of air is necessary along the path of the fibers to the collection zone.

In overall operation, a system as illustrated in the foregoing described figures can function as a stable dynamic fiber-forming facility only if fibers can be attenuated and collected continuously at constant velocities from each feeder. This is made possible in the present instance by a winder which sequentially transfers the attenuated strands from completed packages to empty packages with negligible change in attenuation speed immediately upon completion of each packaging cycle. The strands can thus be drawn downwardly constantly at the high linear velocities to which such fiber formation is adapted.

Stability in atmospheric conditions is promoted by providing the air flow from the outlets **19***a*, **19***b* and **19***c* strategically located in a distributed pattern on opposite sides of the feeders and from above the center aisle between the rows of feeders. Since a constant widespread downward flow of air is thus assured, the dynamic flow conditions in the entire fiber-forming room is maintained uniform and stable with negligible effects being experienced in any one position due to operation of adjacent positions.

Stability is further promoted in each operating position by location of the air outlets so that the pressurized ejection of the air in a sense provides air curtains or walls to protect the forming operation at each feeder from extraneous air movements such as are generated by an operator moving in the vicinity of a forming position. The air curtain further strips the atmosphere in the forming area of contaminants which might be present, and also replaces the air withdrawn by the downward movement of the filaments to the winder.

Moveable louvers **35***a*, **35***b* and **35***c*, are provided in the outlets **19***a*, **19***b* and **19***c* respectively to assist in directioning of the air for establishment of the most stable flow in the forming zone. In this respect, the louvers closest to the feeder are directed toward the fan of fibers attenuated from the feeders **10** and each successive louver following those in closest proximity to the feeders are directed more vertically until the furthermost louver in each outlet is the most vertical. In this way, air is in a sense introduced uniformly across the ceiling to equalize the introduction of air and provides a more uniform distribution of downwardly flowing air in the forming room. Likewise louvers in the central openings **19***c* are more vertically aligned in the central portion and are fanned outwardly in opposite directions with each successive louver away from the center.

As indicated above, the air introduced into the forming room is cooled air thus adding to the comfort of the operators. Correspondingly, the air is conditioned for a relatively fixed humidity rather than being subjected to the variances of the outside atmosphere. It has been found that humidity control is as important a factor in establishing stability of operation as temperature control. Under these conditions of operation, the variables of temperature, humidity and pressure in the fiber-forming zone are all made relatively stable, both as to magnitude at any given instant as well as from one instant to another.

By way of example, it has been found that commercial installations function successfully when the sliver or forming room level is maintained at a general temperature level of 80° F. and a relative humidity of 66 percent. The temperature and humidity are maintained at the desired levels by suitable automatic controls including sensing and adjustment components associated with the condtioning apparatus. Although the amount of air consumed is dependent upon the space and area provided for the forming poistions, it has been found by way of example that continuity and high operating efficiencies can be attained by supplying air at rates in the range of from 1,000 to 1,500 c.f.m. from each of the forming room duct outlets in a production facility of the type exemplified in FIGURE 2. Although such rate of supply is not exactingly calculable, adjustments can be made at individual positions for the proper balance and the greatest efficiency of production by trial and error monitored observation over a period of time before the final dynamic conditions are fixed.

The negative or reduced pressure at the basement level is correspondingly established at a value which will assure acceptance of the air introduced from above. In this respect the exhaust system is designed to accommodate the air and also to overcome the resistance to flow presented in the circuit or loop within which it is circulated. The openings adjacent the feeders are made generally as long as the feeder itself, while their width is governed by the area which will establish the desired pressure of air upon release in the zone of the feeders to provide downward air curtains for stripping the feed ing zone of contaminants and effectively isolating it from surrounding atmospheric conditions.

The louvers **35***a*, **35***b* and **35***c* in the openings are corespondingly adjusted so that the minimum tendency toward disturbance is established in the immediate fiber-forming zone, and at the same time providing the downward curtain effect at each successive point away from

the feeder to the furthest edge of each of the openings, where the air is pressure ejected more directly downward to, in a sense, form a downwardly moving air wall on opposite sides of the feeder. Tests indicate that air introduction on two longitudinal opposing sides of the feeder is adequate to establish this protective wall since the remaining free sides in the usual feeder present only narrow moving faces of the fan of fibers which are also subjected to the influence of the air walls. If the side dimensions were to be made appreciable, however, air walls or curtains on more than two sides can be provided, if desired.

It has been found, in general, that the magnitude of the variables is not as important as preventing the transient conditions from affecting any one such variable. It appears that transients shock the fiber-forming operations and promote discontinuities. When the variables, however, are maintained constant at suitable operating magnitude, such disruptions are minimized and operation of a bank of one hundred or more of such units in a given eight-hour period can be maintained constant with 100% output in full packages. That is, operation of one hundred or more of such units can be accomplished over an eight-hour period with no breakouts whatsoever. Operation at these high levels of efficiency have been unattainable heretofore.

It will be understood from the foregoing that, although I have shown a certain particular form of my invention, I do not wish to be limited specifically thereto since many modifications may be made within the basic concepts of the invention. For example, the levels of the forming room and the winding room might be modified in dimension and proportion, and correspondingly the openings, and the shape of the arcuate members guiding the air downwardly along the length of the fibers and strands being attenuated can be modified without deviating from my basic inventive concepts. Accordingly, I contemplate that the appended claims cover all modifications which fall within the true spirit and scope of my invention.

I claim:

1. In apparatus for the production of continuous fibers of molten heat fiberizable materials comprising a feeder supplying streams of such material, means for attenuating and collecting said streams of material in the form of continuous fibers, means for supplying air conditioned at a desired temperature in the form of air streams projecting generally downward on opposite sides of said feeder and generally parallel to the path of movement of said fibers toward said collection means, a fluid cooled member on at least one side of said feeder having an exposed cooled surface extending for a substantial portion of the length of said feeder between said feeder and at least one of the downwardly projecting air streams, and means for establishing a zone of reduced pressure opposite said attenuating and collecting means from said feeder, said pressure reducing means being adapted to withdraw air from the general vicinity adjacent said attenuating and collecting means away from the path of said fibers.

2. Appartus for the production of continuous fibers according to claim **1** wherein fluid cooled members are located on opposite sides of said feeder each being disposed between said feeder and a downwardly projecting air stream.

3. Apparatus for the production of continuous fibers according to claim **2** wherein the cooled members are cooled by water passed through the members.

No references cited.

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